Evaluating the Cost and Supply of Alternatives to MTBE in California's Reformulated Gasoline

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California Energy Commission

Fuel Resources Office

Current as of October 23, 1997

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MTBE ALTERNATIVE SUPPLY STUDY

The Energy Commission has been directed by the Legislature to perform a study examining the potential impacts on the supply and price of gasoline for California if MTBE were to be banned or reduced in volume. The report will address:

- The expected impact of various scenarios on the ability of both California refiners and outside companies to produce complying California Air Resources Board reformulated gasoline (CARB RFG), including cost and time frames necessary to transition to the various alternatives.

- Evaluation of the alternatives available to refiners, including ethanol, ETBE, TBA, TAME, alkylates and other high octane blending components.

Background

On May 12, 1997, the California Legislature held a hearing to consider a proposed ban of MTBE in California. The Energy Commission testified that preliminary estimates indicated that the short-term impact on reformulated gasoline production capability for California refineries would be, at a minimum, a decrease in the range of 15 to 40 percent by volume. The resulting price spikes and probably spot shortages would have a dramatic impact on California consumers.

Subsequently, the Legislature directed the Energy Commission to further refine their initial estimates and broaden the analysis of the potential impacts of an eventual ban or reduction in the use of MTBE. Specifically, the language states:

(a) On or before January 10, 1997, the commission shall, as part of the ongoing analysis of fuel price and supply required to be undertaken pursuant to Chapter 4.5 (commencing with Section 25350) of the Public Resources Code, and using existing staff and fiscal resources, prepare and submit to the Legislature a report which contains all of the following:

(1) a detailed evaluation of alternative additive s and compounds which could be used in lieu of Methyl Tertiary Butyl Ether (MTBE) in gasoline in California.

(2) an evaluation of the relative air quality and environmental benefits associated with each alternative additive or compound when compared to MTBE.

(3) an estimate of the potential costs or savings to the public in increases or decreases in retail gasoline prices for each alternative when compared to MTBE.

(4) an evaluation of the present and future availability of each alternative as compared to the availability of MTBE.

(5) an evaluation of the minimum time frames within which one or more alternatives could be substituted for MTBE without resulting in significant disruption of gasoline supply.

Workplan

In order to fulfill the requirements of the Legislature's directive, the Commission developed a draft work plan that addresses the supply and cost impacts of banning or reducing the amount of MTBE in CARB RFG. The workplan is broken down into three main areas of study: refinery modeling, oxygenates availability, and California import capability. A contractor has been selected for each of these three areas. The Energy Commission will coordinate the work of these three contractors in a process designed to be interactive and mutually supportive.

- **Refinery Modeling (MathPro).** This contractor will evaluate the effects of different economic conditions, raw material costs, varying refined product specifications, and alternative oxygenate use on overall fuel production costs.

- **Oxygenates Availability (Energy Security Analysis, Inc.).** This contractor will develop an alternative oxygenates implementation strategy for California which identifies each oxygenate, its availability and cost in the intermediate and long term. In addition, the contractor will determine the timeframe and cost to upgrade California's distribution terminals to make them compatible with the alternative oxygenate.

- **California Import Capability (Purvin & Gertz).** The primary responsibility of this contractor is to provide estimated costs of imports of reformulated gasoline to the California market to make up for any shortfall that may occur under any of the scenarios run by the refinery modeling contractor. This contractor will also examine the marine transportation infrastructure to determine what constraints may exist which would limit the ability of industry to move additional refined products through the system.

Purpose of Workshop

The workshop will focus on presenting the various workplans and assumptions that the Energy Commission expects to use in this study. A staff overview of the scope of the work will be presented. Each contractor will provide a summary of their methodology and how they plan to meet the objectives of the study. After the presentations, staff and contractors will answer any questions and address any concerns of the participants. The public will have an opportunity to make oral presentations at the workshop or submit written comments to the docket by November 5, 1997.

Outcome

The outcome will be a final workplan complete with assumptions that will be used in the study. The original assumptions may be replaced with those presented at the workshop or submitted in writing if appropriate.

Evaluating the Cost and Supply of Alternatives to MTBE in California's Reformulated Gasoline

Study Workplan

Refinery Modeling Subcontractor

Oxygenate Subcontractor

World Refining Subcontractor

California Energy Commission

Fuel Resources Office

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Refinery Modeling Workplan

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Refinery Modeling Subcontractor

The main responsibilities of the Refinery Modeling Subcontractor will be to construct and calibrate a model for the aggregated statewide refinery system of California, and operate this refinery model under a variety of scenarios, using a number of alternative oxygenates. The purpose of these sensitivity runs will be to calculate what the effect will be on the cost of producing reformulated gasoline in California, compared to the base case of producing reformulated gasoline using MTBE, as well as to examine the volume and cost impacts on the rest of the product slate.

Tasks

The Refinery Modeling Subcontractor will perform the following tasks:

Task 1 Make a presentation of planned work at the public workshop and then finalize the report on the scenarios and assumptions used in the model.

Task 2 Calibrate the California statewide aggregated base case refinery model.

Task 3 Complete each supply scenario refinery modeling run and prepare a report on the findings.

TASK 1: PREPARE A REPORT ON SCENARIOS AND ASSUMPTIONS USED IN THE MODEL

Scenarios and assumptions are to be developed and presented at a public workshop. Based on the comments received both during the workshop and in writing, the scenarios and assumptions will be amended by the Refinery Modeling Subcontractor and presented as a final report. **Table 1** is a matrix illustrating the various scenarios and individual cases to be examined over the intermediate and long -term time periods.

Scenario Time Periods

Each of the following modeling scenarios will be subdivided into two distinct time periods: intermediate-term and long-term. The near-term time period will not be included in the refinery modeling runs but will be examined to determine what limiting factors could interfere with a smooth transition to an alternative oxygenate.

Table 1 - Refinery Modeling Scenarios

Scenario		Case	Case Remarks	MTBE	ETOH	ETBE	TBA	Mixed* Oxygenates	Air Quality Implications
Base Case	A	MTBE Used		1	0	0	0	0	NO
	B	MTBE Used and HR 630		1	0	0	0	0	NO
California Ban on MTBE	A	Current Regulations In Place		0	1	1	1	1	NO
	B	HR 630	O_2 can go below 1.5% wt.	0	1	1	1	1	NO
	C	ETOH Granted Waiver	7.8 RVP & 3.5% wt. O_2	0	1	0	0	0	YES
	D	No Tax Credits for ETOH & ETBE		0	1	1	0	1	NO
	E	No Tax Credits & HR 630		0	1	1	0	1	NO
	F	No Tax Credits & ETOH Waiver	7.8 RVP & 3.5% wt. O_2	0	1	1	0	1	YES
US-wide Ban on MTBE	A	Current Regulations In Place		0	1	1	1	1	NO
	B	HR 630	O_2 can go below 1.5% wt.	0	1	1	1	1	NO
	C	ETOH Granted Waiver	7.8 RVP & 3.5% wt. O_2	0	1	0	0	0	YES
	D	No Tax Credits for ETOH & ETBE		0	1	1	0	1	NO
	E	No Tax Credits & HR 630		0	1	1	0	1	NO
	F	No Tax Credits & ETOH Waiver	7.8 RVP & 3.5% wt. O_2	0	1	1	0	1	YES

*Mixed Oxygenates - Will use an economically optimal combination of ETBE, TAME, and TBA.

Current Regulations - Existing California and Federal standards are in effect for CARB RFG.

HR 630 - Refiners are allowed to blend CARB RFG with an oxygen content less tha 1.8 weight percent throughout the entire state during the non-winter months.

ETOH Waiver - During the non-winter months, refiners will blend CARB RFG with a 1.0 psi Rvp waiver for ethanol which is expected to result in a 7.8 psi Rvp for the finished blend of CARB RFG. The oxygen content will have to be at 3.5 weight percent to be granted the Rvp waiver.

No Tax Credits - Existing federal tax credits for producers and blenders of ethanol and ETBE are eliminated.

Near-term A "limiting factor" shall be determined for each scenario category. For example, displacement of MTBE with ethanol could not reasonably be accomplished until the distribution infrastructure has been modified to allow splash-blending of ethanol at refineries and all terminals downstream of the refineries.

Intermediate-term shall refer to the time period that is long enough to allow the alternative oxygenate for each scenario category to achieve a new equilibrium level. Minor refinery modifications (such as debottlenecking) are permitted during this period of time. All targeted refined product demand levels are to be met through a combination of California refinery production and imports. These demand targets will be different from the near-term volumes.

Long-term shall refer to the time period that is long enough to allow major refinery modifications (such as new process units) to be accomplished, if necessary, to increase refinery production capacities. The alternative oxygenate for each scenario category is assumed to be at the equilibrium level of the intermediate-term scenario. All targeted refined product demand levels are to be met through a combination of California refinery production and imports. These demand targets will be different from the intermediate-term volumes

Scenario Descriptions

Scenario 1: An alternative oxygenate completely displaces MTBE.

- ETOH, ETBE, TBA and mixed oxygenates.

MTBE is assumed to be banned in California only, while all other federal and state regulations concerning reformulated gasoline remain in effect.

For each of the scenarios involving ethanol, California refiners are assumed to be producing a type of base gasoline (referred to as CARBOB) that will be blended with ethanol at the terminals using sequential or in-line blending equipment. Specifications for these blends should reflect a lower Rvp and other characteristics that take into account what the finished specifications will be after the oxygenate is combined with the base gasoline blending stock.

For each of the scenarios involving ETBE and TBA, California refiners are assumed to be producing a finished blend of reformulated gasoline (referred to as CARB RFG) that will contain one of these alternative oxygenates. The mixed oxygenates scenario involves the Refinery Modeling Subcontractor selecting the economically optimal mix of ETBE, TAME and TBA.

Scenario 2: MTBE is banned in California, while certain aspects of federal RFG regulations are relaxed.

- ETOH, ETBE, TBA and mixed oxygenates.

Specifically H.R. 630 passes CARB RFG producers are permitted to sell CARB RFG during the summer months that contains an amount of oxygen below the federal minimum of 1.5 weight percent. Currently, all ozone nonattainment regions in California are not permitted to sell CARB RFG that contains an oxygen content that is below this minimum at any time during the year. Under this scenario it is assumed that the whole state will be allowed to drop below this minimum.

California refiners are assumed to use the CARB RFG Predictive Model, thereby creating the possibility of reducing the use of an oxygenate below the minimum 1.5 percent by weight oxygen during the non-winter months. This scenario is similar to the type of work that would be expected to be performed to complete scenario 1 of Task 2.

Scenario 3: MTBE is banned in California and a one pound Rvp waiver is allowed for use of ethanol, along with an oxygen content of 3.5 weight percent. All other federal and state regulations remain in effect.

California refiners are assumed to be producing a type of CARBOB that will be blended with ethanol at the terminals using sequential or in-line blending equipment. Specifications for these blends should reflect a slightly higher Rvp (compared to scenario 1) and other characteristics that take into account what the finished specifications will be after the ethanol is added to the base gasoline or CARBOB.

Scenario 4: MTBE is banned in California, while federal tax incentives for ethanol and ETBE are eliminated. Includes excise tax credits and producers' tax credits. Similar to scenario 1 of Task 2, but does not examine TBA.

- ETOH, ETBE and mixed oxygenates.

Scenario 5: MTBE is banned in California, federal tax incentives for ethanol and ETBE are eliminated and the minimum oxygen content is allowed to drop below 1.5 weight percent during the non-winter months. This sensitivity is a combination of scenarios 2 and 4 of Task 2.

- ETOH, ETBE and mixed oxygenates.

Scenario 6: MTBE is banned in California, federal tax incentives for ethanol and ETBE are eliminated and a one pound Rvp waiver is allowed for use of ethanol, along with an oxygen content of 3.5 weight percent. This sensitivity is a combination of scenarios 3 and 4 of Task 2.

- ETOH, ETBE and mixed oxygenates.

Scenario 7: MTBE ban is extended to the rest of the United States throughout the two time periods. Similar to scenarios 1 through 6 of Task 2.

- ETOH, ETBE, TBA and mixed oxygenates.

Assumptions

Part of the basis for this study will be a list of assumptions that will define: the parameters of the various inputs that will be integrated into the refining modeling analysis, the regulatory framework that will exist at the state and federal level, the types and ranges of specifications that the refined products will have to meet to be complying, and the status of MTBE outside of California. Some of these assumptions will be modified for specific scenarios.

- Assume MTBE is banned and other ethers and alcohols are still acceptable.
- Assume California Phase 2 RFG specifications in effect.
- Assume that federal RFG regulations (with regard to minimum oxygen standards) will be in effect.
- Assumptions on refinery process units (see below).
- Assumptions on refinery inputs (see below).
- Assumptions on refined product specifications (see below).
- Assumptions on refined product slate outputs (see below).
- Assumptions on Base Case supply/demand (see below).

Refinery Process Unit Assumptions

For the aggregated statewide modeling portion of the analysis, the following information on process units will need to be provided and agreed to be used as the basis for the Base Case and various Supply Scenario modeling runs:

- Statewide aggregated throughput capacity (barrels per stream day) for the various process unit types. The following list is an example of some of the potential process units that will be modeled and could even be expanded or reduced based upon future revisions :
  - Atmospheric crude towers
  - Crude vacuum
  - Diesel and naphtha hydrotreating
  - Lite distillate hydrofining
  - Gas oil and cycle oil hydrofining
  - Fluid catalytic cracking
  - Hydrocracking
  - Fluid and delayed coking
  - Aromatic hydrogenation
  - Super fractionation
  - Light and heavy naphtha reforming
  - Butylene, propylene, and amylene alkylation
  - Butane isomerization
  - C5-C6 isomerization
  - Aromatics saturation and separation
  - Sulfur plant extraction
  - MTBE and TAME capacity
  - Hydrogen capacity
  - Steam capacity
  - Cogeneration capacity

- Linkage between the various process units.

- Conversion rates of the various process units (percentage of different blending components that are produced and qualities of these process streams).

Refinery Input Assumptions

For the aggregated statewide modeling portion of the analysis, the following information on refinery inputs will need to be provided and agreed to be used as the basis for the Base Case and various Supply Scenario modeling runs:

- Source and characteristics of crude oil supplied (these qualities are assumed to remain unchanged throughout the two time periods):
  - API gravity
  - sulfur content (ppm)
  - nitrogen content (ppm)
  - aromatic content (lv. %)
  - diluent content (lv.%)

- Source and characteristics of other refinery inputs supplied to the refinery from outside the facility:
  - oxygenates
  - alkylates and other blending components
  - unfinished oils and other process unit feedstocks

- Blending characteristics of process streams for the various intermediate and final blending components for gasoline and other refined products:
  - Distillation temperatures (T10, T50, T90)
  - Sulfur content (ppm)
  - Aromatic content (lv. %)
  - Olefin content (lv. %)
  - Benzene content (lv. %)
  - Oxygen content (wt. %)
  - Octane blending value ((R+M)/2)
  - Blending Rvp value (psi)
  - API gravity

Refined Product Specification Assumptions

For the aggregated statewide modeling portion of the analysis, the following information on refined product specifications will need to be provided and agreed to be used as the basis for the Base Case and various Supply Scenario modeling runs:

- Gasoline specifications (summer season only):
  - CARB RFG (using Predictive Model - Flat Limits)
  - AZ RFG (for export)
  - Conventional (for export)
  - Aviation gasoline

- Distillate specifications:
  - Low sulfur
    - CARB LAD
    - EPA LS
  - High sulfur

- Kerosene type jet fuel specifications:
  - Commercial grade
  - Military grade

- Residual fuel oil specifications.

- Lube oil and miscellaneous refined product specifications.

Refined Product Slate Output Assumptions

Relative volumes will be based on the historic numbers covering the time period May through August 1997. The assumption is that this volume breakdown of the refined product slate will be the output goal of the Base Case modeling run. Different volumes for each of the refined products will be calculated, depending on which time period is being examined for each of the various Supply Scenario modeling run. For the aggregated statewide modeling portion of the analysis, the following information on refined product slate outputs will need to be provided and agreed to be used as the basis for the Base Case and various Supply Scenario modeling runs.:

- Gasoline volumes, including percentage of each grade (where applicable):
  - CARB RFG
  - AZ RFG (for export)
  - Conventional (for export)
  - Aviation gasoline

- Distillate volumes:
  - Low sulfur
    - CARB LAD
    - EPA LS (for in-state use and export)
  - High sulfur (for in-state use and export)

- Kerosene type jet fuel volumes (for in-state use and export):
  - Commercial grade
  - Military grade

- Residual fuel oil volumes (for in-state use and export):

- Lube oil and miscellaneous refined product volumes (for in-state use and export):

Base Case Supply and Demand Assumptions

For the aggregated statewide modeling portion of the analysis, the following information will need to be provided and agreed to be used as the basis for the Base Case and various Supply Scenario modeling runs:

- Base Case inputs and outputs are assumed to be those from the period May through August 1997, for the 13 California refineries that were producing CARB RFG during this period of time.

- Refined product target goals for the Base Case output are assumed to be the California Supply number calculated from the EIA 810 and CEC M07 submittals, for the companies that represent the 13 California refineries that were producing CARB RFG during the time period May through August 1997. Additional refined product target goals will be calculated by the CEC for each of the time periods that will be associated with the various Supply Scenario runs.

- Imports of CARB RFG are assumed to vary from one Supply Scenario run to the next, depending on the degree of refined product production shortfall or import economics incentives, if any.

TASK 2: CALIBRATE CALIFORNIA STATEWIDE AGGREGATED BASE CASE REFINERY MODEL

The Refinery Modeling Subcontractor will receive statewide aggregated PIIRA refinery input totals from CEC for the time period of May through August 1997. Data will be provided to the Refinery Modeling Subcontractor by the CEC in a format suitable to facilitate incorporation into the LP model. Additional data will also be submitted to the CEC from the individual refiners on process unit capacities, average yields and any other information deemed relevant and necessary to complete the calibration of the refinery model. This information will be aggregated by the CEC staff prior to being provided to the Refinery Modeling Subcontractor.

Output from the LP run will be compared to the actual outputs over the same period of time. Outputs are expected to be within **0.5 percent** by volume for each of the refined products before the Base Case model can be deemed “calibrated”. The Refinery Modeling Subcontractor shall prepare a final report that details each of the inputs and outputs, as well as the primary assumptions that were used in the Base Case LP run.

TASK 3: COMPLETE EACH SUPPLY SCENARIO REFINERY MODELING RUN AND PREPARE A REPORT ON THE FINDINGS

The Refinery Modeling Subcontractor will provide a draft and final report that details the results of each of the Supply Scenario modeling runs. Along with the assumptions, the supply analysis is expected to consist of some minimum level of information. Examples of the minimum level of information expected from each of the LP refinery modeling runs are the following:

- Base Case for each of the two time periods that will utilize MTBE as the oxygenate. This refinery modeling run will be used as a basis of comparison to each of the alternative scenarios.

- Production volumes expressed in thousands of barrels per stream day for the summer season (low Rvp with no scheduled maintenance).

- Refinery inputs, their costs and volumes.

- Refinery output costs by refined product type, including valuation of distressed cargoes.

- Volume of imports required to balance out CARB RFG supply/demand.

- Minor refinery modifications incorporated in intermediate time period scenario runs.
  - Types, costs and minimum time frames required..

- Major refinery modifications incorporated in long-term time period scenario runs.
  - Types, costs and minimum time frames required..

- Cost estimates of oxygenates for each scenario will be provided to the Refinery Modeling Subcontractor by the Oxygenate Subcontractor.

- Cost estimates of imports for each scenario will be provided to the Refinery Modeling Subcontractor by the World Refinery Subcontractor.

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Oxygenate Workplan

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California Energy Commission

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Oxygenate Subcontractor

The main responsibilities for the Oxygenate Subcontractor will be to assess the overall alternative oxygenate supply/demand situation for present and future costs for each of the various scenarios. In addition, the Oxygenate Subcontractor will identify any infrastructure improvements at the refinery or at the distribution terminals that may be necessary so that the industry is able to overcome any handling issues associated with any of the alternative oxygenates.

Tasks

The Oxygenate Subcontractor will perform the following tasks:

Task 1 Make a presentation of planned work at public workshop.

Task 2 Prepare a report on current production capacity for oxygenates and the ability of the oxygenate industry to increase production capacity.

Task 3 Prepare a report on California refinery infrastructure improvements required for alternative oxygenates.

Task 4 Prepare a report on California distribution infrastructure improvements required for alternative oxygenates.

TASK 1: MAKE A PRESENTATION OF PLANNED WORK AT THE PUBLIC WORKSHOP

The Oxygenate Subcontractor shall prepare a presentation for the public workshop. This presentation will contain a thorough explanation of all the work that will be covered under the tasks associated with this subcontract. Descriptions of the various assumptions, scenarios, and general approaches undertaken as part of this work should be the subject matter covered during the presentation. The Oxygenate Subcontractor is also expected to respond to questions raised throughout the public workshop that pertain to their area of involvement and expertise.

TASK 2: PREPARE A REPORT ON THE CURRENT PRODUCTION CAPACITY FOR OXYGENATES AND THE ABILITY OF THE OXYGENATE INDUSTRY TO INCREASE PRODUCTION CAPACITY

The Oxygenate Subcontractor will prepare a report that details the world's current oxygenate nameplate capacities, by country, by state, by company and by oxygenate type. This report will also contain a list of the plants that are currently idle and a list of those facilities that are undergoing expansions or have commenced new construction. The types of oxygenates contained in this report shall be MTBE, ETBE (with notation indicating which facilities have dual-capability for MTBE and ETBE production), TAME, ETOH and TBA (if applicable).

The Oxygenate Subcontractor will prepare for the same report an assessment of the production costs and time periods associated with meeting additional demand levels from the various supply regions. The time periods shall cover the intermediate and long term periods.

The demand for the various types of oxygenates is expected to vary depending on the results of the various scenarios being run by the Refinery Modeling Subcontractor. Supply cost information shall consist of the various capital and incremental operating costs that are associated with increased capacity improvements. Supply costs should be broken down by each of the various types of expansion projects (increased existing, new construction and conversions). Transportation costs to California and estimated margins necessary to import specific ranges of products are also expected to be included in the report, resulting in a "delivered cost" for each of the various oxygenates. The Oxygenate Subcontractor will account for all the various demands for each of the different oxygenates, regardless of their end use, and determine what the overall impact is on the price of oxygenates in the market. These price projections should be on an annual basis and cover the present (1997) through the year 2003.

In addition to supply cost estimates for the alternative oxygenates, the Oxygenate Subcontractor will provide an estimated supply cost for MTBE over the three time periods that will be used as part of the Base Case analysis. The delivered cost information for the Base Case MTBE should also differentiate the various demands for MTBE on a global scale (broken down by region and end use) and the supply region source for the MTBE imported into California. The assumption for the Base Case is that MTBE is not banned in either California or the rest of the United States.

Scenario Time Periods

Each of the following scenarios will be subdivided into two time periods: intermediate-term and long-term. The near-term time period will be examined to determine what limiting factors could interfere with a smooth transition to an alternative oxygenate.

Near-term A "limiting factor" shall be determined for each scenario category. For example, displacement of MTBE with ethanol could not reasonably be accomplished until the distribution infrastructure has been modified to allow splash-blending of ethanol at refineries and all terminals downstream of the refineries.

Intermediate-term shall refer to the time period that is long enough to allow the alternative oxygenate for each scenario category to achieve a new equilibrium level. Minor refinery modifications are permitted during this period of time.

Long-term shall refer to the time period that is long enough to allow major refinery modifications to be accomplished, if necessary, to increase refinery production capacities. The alternative oxygenate for each scenario category is assumed to be at the equilibrium level of the intermediate-term scenario.

Scenario Descriptions

Scenario 1: An alternative oxygenate is used to replace MTBE, which has been banned in California only. All other federal and state regulations concerning reformulated gasoline remain in effect.

- ETOH, ETBE, TBA and TAME.

The Oxygenate Subcontractor will provide the estimated costs at which different volumes of these alternative oxygenates could be supplied to California. The Oxygenate Subcontractor shall account for all the various demands on a global scale (broken down by region and end use) for the alternative oxygenates, besides that required for blending to produce CARB RFG.

Scenario 2: MTBE is banned in California, while federal tax incentives for ethanol and ETBE are eliminated on a national level. Includes all excise tax credits and producers' tax credits. Similar to Scenario 1 of Task 2.

- ETOH and ETBE

Scenario 3: MTBE ban is extended to the rest of the United States throughout the two time periods. Similar to Scenarios 1 and 2 of Task 2.

- ETOH, ETBE, TBA and TAME

TASK 3: PREPARE A REPORT ON CALIFORNIA REFINERY INFRASTRUCTURE IMPROVEMENTS REQUIRED FOR ALTERNATIVE OXYGENATES

The Oxygenate Subcontractor will identify what specific infrastructure improvements (inside the refinery gate) would be required to allow California refiners to utilize each of the potential alternative oxygenates. This information should include estimates of the types of improvements, their associated costs and time frames that would be needed to complete specific refinery modifications, if any.

TASK 4: PREPARE A REPORT ON DISTRIBUTION INFRASTRUCTURE IMPROVEMENTS REQUIRED FOR ALTERNATIVE OXYGENATES

Such details as nature of improvements, their associated costs and time frames will be part of this response. With regard to the ethanol scenario, the Oxygenate Subcontractor will be expected to provide an assessment of the current status of California's downstream infrastructure. Results of this investigation will be aggregated on a statewide basis.

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World Refining Workplan

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World Refining Subcontractor

The primary responsibility of the World Refining Subcontractor will be to provide estimated costs of imports of reformulated gasoline to the California market to make up for any shortfall that may occur under any of the scenarios run by the Refinery Modeling Subcontractor. The World Refining Subcontractor will also be expected to provide some volume and cost estimates of importing alkylates and various high octane blending components.

Further, the World Refining Subcontractor will prepare a report that details the capability of the marine transportation infrastructure to handle additional imports of refined products and additional exports of distressed cargoes. Finally, the World Refining Subcontractor will be responsible for preparing the Final Report that summarizes the various reports prepared by all the other subcontractors.

Tasks

The World Refining Subcontractor will perform the following tasks:

Task 1 Make a presentation of planned work at the public workshop.

Task 2 Prepare a report on California reformulated gasoline production outside the state.

Task 3 Prepare report on marine transportation infrastructure for importing reformulated gasoline.

Task 4 Prepare a report on markets outside the state impacted by exporting cargoes to California.

Task 5 Prepare draft and final reports for the MTBE Alternative Supply Study and present results at the hearing.

TASK 1: MAKE A PRESENTATION OF PLANNED WORK AT THE PUBLIC WORKSHOP

The World Refining Subcontractor shall prepare a presentation for the public workshop. This presentation will contain a thorough explanation of all the work that will be covered under the tasks associated with this subcontract. Descriptions of the various assumptions, scenarios, and general approaches undertaken as part of this work should be the subject matter covered during the presentation. The World Refining Subcontractor is also expected to respond to questions raised throughout the public workshop that pertain to their area of involvement and expertise.

TASK 2: PREPARE A REPORT ON THE CURRENT AND FUTURE STATUS OF CALIFORNIA REFORMULATED GASOLINE PRODUCERS OUTSIDE OF THE STATE

The World Refining Subcontractor shall prepare a report that contains a current list of supply regions, their product capacity by type and company. Supply regions shall be broken down into: the U.S. Gulf Coast, The U.S. Pacific Northwest, Caribbean, Europe, Latin America, Middle East, and the Far East. Products shall include CARB reformulated gasoline, alkylates and high octane blending components (if appropriate).

The report will also contain a list of the various supply regions outside of California that could be expected to increase their capability to produce CARB RFG, alkylates and certain high octane blending components. The report will detail the various costs incurred and time frames involved to achieve a specified range of additional demand through expansion of existing capacity and construction of new facilities. The types of products being produced by refiners outside of California shall correspond to the scenarios detailed below. The time periods shall cover the intermediate and long-term periods.

It should be noted that if the results of one or more of the scenarios being run by the Refinery Modeling Subcontractor indicate that a significant increase in imports is needed to meet demand, the World Refining Subcontractor may determine that there is insufficient marine transportation infrastructure capacity to accommodate the increased volume of imports. As a result, additional time may be needed to upgrade these facilities and this period of time could be the limiting factor with regard to one or more of the time periods.

The costs of these additional imports are expected to vary depending on the level of increased import demand necessitated by the results of the various scenarios being run by the Refinery Modeling Subcontractor. Cost information shall consist of the various capital and incremental operating costs that are the basis for the plant gate cost estimates. Transportation costs to California and estimated margins necessary to import specific ranges of products are also expected to be included in the report, resulting in a “delivered cost” for the CARB RFG, alkylates and high octane blending components.

Scenario Time Periods

Each of the following scenarios will be subdivided into two distinct time periods: intermediate-term and long-term.

Intermediate-term shall refer to the time period that is long enough to allow the alternative oxygenate for each scenario category to achieve a new equilibrium level. Minor refinery modifications are permitted during this period of time. Major modifications can be made at the marine terminals if handling or capacity limitations are identified. The level of import demand for each of the scenarios will be determined by the Refinery Modeling Subcontractor

Long-term shall refer to the time period that is long enough to allow major refinery modifications to be accomplished, if necessary, to increase refinery production capacities. The alternative oxygenate for each scenario category is assumed to be at the equilibrium level of the intermediate-term scenario. The level of import demand for each of the scenarios will be determined by the Refinery Modeling Subcontractor.

Scenario Descriptions

Scenario 1: An alternative oxygenate completely displaces MTBE.

- ETOH, ETBE and TBA

MTBE is assumed to be banned in California only, while all other federal and state regulations concerning reformulated gasoline remain in effect.

For each of the scenarios involving ethanol, refiners outside of California are assumed to be producing a type of base gasoline (referred to as CARBOB) that will be exported to California and blended with ethanol at the terminals using sequential or in-line equipment. Specifications for these blends should reflect a lower Rvp and other characteristics that take into account what the finished specifications will be after the oxygenate is combined with the base gasoline blending stock. The World Refining Subcontractor will provide the estimated costs at which different volumes of exports could be shipped to California throughout the two different time periods. The Oxygenate Subcontractor will provide the costs used for the ethanol that will be splash-blended with the CARBOB.

For each of the scenarios involving ETBE and TBA, refiners outside of California are assumed to be producing a finished blend of reformulated gasoline (referred to as CARB RFG) that will contain one of these alternative oxygenates. This finished product will then be exported to California. The World Refining Subcontractor will provide the estimated costs at which different volumes of exports could be shipped to California throughout the two different time periods. The Oxygenate Subcontractor will provide the oxygenate prices used as part of the production cost estimates.

Scenario 2: MTBE is banned in California, while certain aspects of federal RFG regulations are relaxed.

- ETOH, ETBE and TBA

Specifically H.R. 630 passes CARB RFG producers are permitted to sell CARB RFG during the summer months that contains an amount of oxygen below the federal minimum of 1.5 weight percent. Currently, all ozone nonattainment regions in California are not permitted to sell CARB RFG that contains an oxygen content that is below this minimum at any time during the year. Under this scenario it is assumed that the whole state will be allowed to drop below this minimum.

Refiners outside of California are assumed to use the CARB RFG Predictive Model, thereby creating the possibility of reducing the use of an oxygenate below the minimum 1.5 percent by weight oxygen during the non-winter months. This scenario is similar to the type of work that would be expected to be performed to complete scenario 1 of Task 2.

Scenario 3: MTBE is banned in California and a one pound Rvp waiver is allowed for use of ethanol, along with an oxygen content of 3.5 weight percent. All other federal and state regulations remain in effect.

Refiners outside of California are assumed to be producing a type of CARBOB that will be exported to California and splash-blended with ethanol at the terminals. Specifications for these blends should reflect a slightly higher Rvp (compared to scenario 1) and other characteristics that take into account what the finished specifications will be after the ethanol is added to the base gasoline or CARBOB.

Scenario 4: MTBE is banned in California, while federal tax incentives for ethanol and ETBE are eliminated. Includes excise tax credits and producers' tax credits. Similar to scenario 1 of Task 2, but does not examine TBA.

- ETOH and ETBE.

Scenario 5: MTBE ban is extended to the rest of the United States throughout the two time periods. Similar to scenarios 1 through 4 of Task 2.

- ETOH, ETBE and TBA.

Scenario 6: Additional volumes of alkylates are exported to California.

Refiners and other producers outside of California are assumed to be producing alkylates for use in blending with the components to produce both Federal and CARB RFG. The World Refining Subcontractor will ascertain the current alkylate supply capacity outside of California (by supply region and feed source) and determine what quantities of alkylates can be exported to California throughout the two different time periods. This work will involve estimating the costs required to expand these capacities to meet varying levels of demand that will be determined by the Refinery Modeling Subcontractor.

Demand over the intermediate-term shall be met through a combination of capacity expansions at existing facilities and bidding away supplies from alternative uses. Over the long-term, demand will be met by a combination of capacity expansions at existing facilities and construction of new capacity that results in a new equilibrium price for alkylates.

The World Refining Contractor will quantify, throughout the two time periods, as a part of this task: the impact on alkylate supply/demand markets; impact on alkylate feedstock supply/demand markets (as they compete with the chemical markets); feedstock limiting factors; and time frames necessary to complete the various types of capacity expansions.

Scenario 7: Additional volumes of high octane blending components are exported to California.

Refiners and other producers outside of California are assumed to be utilizing high octane blending components to meet the octane needs of both Federal and CARB RFG. The World Refining Subcontractor will identify and determine what quantities of high octane blending components (by type) could be exported to California throughout the two different time periods. This work will involve estimating the costs required to expand certain existing capacities and determining the price required to attract sufficient supplies away from alternative uses so that varying levels of demand for high octane blending components can be met.

Additional demand for high octane blending components over the intermediate-term shall be met through a combination of capacity expansions at existing facilities and bidding away supplies from alternative uses. Over the long-term, demand will be met by a combination of capacity expansions at existing facilities and construction of new capacity that results in a new equilibrium price for specific high octane blending components.

The World Refining Contractor will quantify, throughout the two time periods, as a part of this task: the impact on various high octane blending component supply/demand markets; feedstock limiting factors; and time frames necessary to complete the various types of capacity expansions.

TASK 3: PREPARE A REPORT DETAILING THE CURRENT AND FUTURE CAPACITY OF CALIFORNIA'S MARINE INFRASTRUCTURE

The World Refining Subcontractor shall prepare a report that describes California's current marine transportation infrastructure for crude oil, refined products, alkylates and high octane blending components. The report shall include as a minimum, the types of ships used (product tankers, marine barges, crude carriers, etc.), storage tank capacities, segregation ability, off-loading pumping rates, draught levels, and wharf space by individual berth space. These berths shall be grouped into two main regions: the Long Beach/Los Angeles Harbor Complex and San Francisco Bay Area harbors. This report will identify specific limiting factors, if any, for these two regions. This report will also include some estimated capital costs and time frames to overcome these limitations.

TASK 4: PREPARE A REPORT ON MARKETS OUTSIDE THE STATE IMPACTED BY EXPORTING CARGOES TO CALIFORNIA

Impacts will include price changes and the new equilibrium prices of the Federal RFG, alkylates and high octane blending components (if appropriate) by supply region that are a direct result of additional exports to California. These price impacts should be broken down depending upon the different ranges of exported volumes and periods of time involved.

TASK 5: PREPARE A DRAFT AND FINAL REPORT FOR THE MTBE ALTERNATIVE SUPPLY STUDY AND PRESENT RESULTS AT HEARING

This task shall require that the World Refining Subcontractor prepare a draft Final Report for review prior to the Hearing, make a presentation on the results at this Hearing and complete the Final Report. The Final Report shall include summaries of the findings made by the other subcontractors

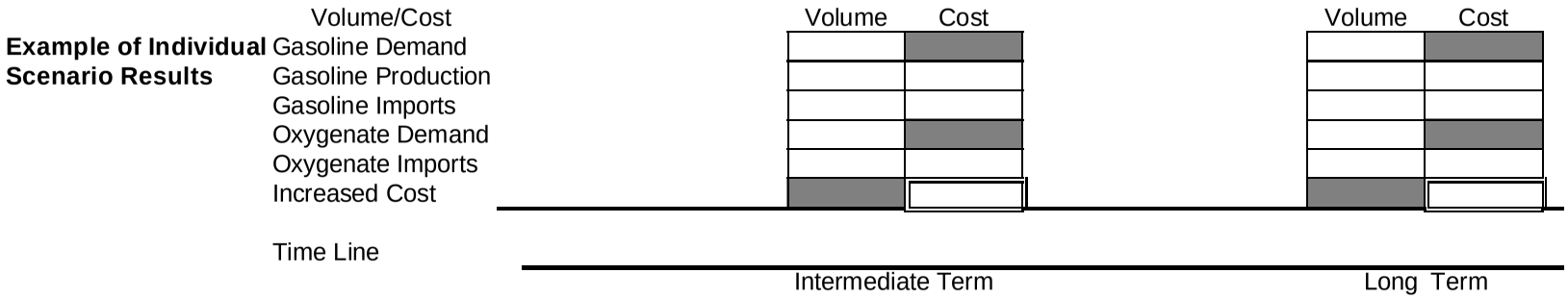
The structure of this Final Report will be designed to break down the results by each of the scenarios that were run by the Refinery Modeling Subcontractor. Each scenario will be described as it relates to the two different time periods (intermediate and long-term). The results for each scenario and time period shall include the estimated increased cost to California's reformulated gasoline market, compared to the base case for each of the two time periods. Additional information will include: total CARB RFG demand, California production volume and costs, level of CARB RFG imports and their costs, oxygenate demand, and level of oxygenate imports and associated costs. **Table 2** illustrates some scenario categories, minimum types of information expected in the summaries and variations in the exact length of time associated with the intermediate and long-term breakdown of each of the individual scenarios.

Although the Refinery Modeling Subcontractor will not be performing an analysis of the impacts in the near-term, the World Refinery Subcontractor will elaborate on some of the issues that would limit the ability of the state to switch to an alternative oxygenate prior to the intermediate time period.

The World Refining Subcontractor will also include in the Final Report other types of information concerning: impacts of alkylates and high octane blending components; disposition of distressed cargoes; marine transportation infrastructure limitations and any other relevant issues raised throughout the entire MTBE Alternative Supply Study process. Each of the reports provided by the various subcontractors shall be summarized and included as part of this Final Report. The individual reports associated with the various tasks shall be compiled as an Appendix to the Final Report. In addition, the World Refining Subcontractor will prepare an Executive Summary, prior to the Hearing.

From this information it is expected that the World Refining Subcontractor will be able to identify the most cost-effective time frame with which to implement each of the various scenarios and summarize the most cost-effective alternatives available to either completely replace the MTBE in California's gasoline with an alternative oxygenate or reduce the volume of MTBE permitted in CARB RFG.

Table 2
Example of Summary Sheet for Final MTBE Alternative Supply Study



Evaluating the Cost and Supply of Alternatives to MTBE in California's Reformulated Gasoline

Oxygenate Information

California Energy Commission

Fuel Resources Office

Current as of October 23, 1997

Oxygenate Information

California and other areas throughout the United States use reformulated gasoline to help reduce emissions of criteria pollutants and achieve compliance with various air quality standards. Oxygenates are a critical gasoline blending component that enables refiners to produce gasoline that conforms to the reformulated specifications. Most oxygenates, except ethanol, are completely compatible with the distribution system and can be easily shipped through pipelines to various locations throughout the state. This fact sheet provides a quick reference on the various types currently being blended into reformulated gasoline (RFG), what California is using, a definition of oxygenates, the intended purposes of their use, and some of the major differences in characteristics that make certain types of oxygenates more desirable than others.

Types: Oxygenates are grouped into two different classes, ethers and alcohols. Currently, there are three different ethers in use throughout the United States. The most popular one is methyl tertiary butyl ether (MTBE), followed by ethyl tertiary butyl ether (ETBE) and tertiary amyl methyl ether (TAME). Ethanol is the only alcohol currently in use as an oxygenate.

California: Refiners in California currently use MTBE (approximately 95,000 barrels per day) and some TAME (about 3,000 barrels per day) to meet all of their oxygenate needs. No ethanol is currently being used in California as an oxygenate due to a variety of factors, namely poor economics, lack of splash-blending equipment and inadequate segregated storage capacity throughout the distribution system, low ethanol supply volumes, distribution difficulties and generally poorer blending characteristics (compared to ethers). Approximately 85 percent of the MTBE used as oxygenates in California is imported from facilities located in the Middle East, Canada and the Gulf Coast of the United States. The remaining 15 percent is produced by California refineries from available feedstocks that are normally generated through the processing of crude oil. These refiners are unable to be completely self-sufficient in ether production because they lack the necessary volumes of feedstocks.

Definition: Oxygenates are a class of compounds that are blended with gasoline to increase the amount of oxygen contained in the fuel. Most petroleum blendstocks that are mixed together to create gasoline contain long chains of hydrocarbons consisting of hydrogen and carbon. It is the addition of oxygenates that provides the source of oxygen in RFG.

Purpose: Oxygenates are used to increase the oxygen content of gasoline so that the fuel will burn more completely in the engine, reducing tailpipe emissions of carbon monoxide. Many regions throughout the United States and especially California are in violation of federal carbon monoxide standards during the winter months and use oxygenated gasoline to reduce the number of violations and achieve compliance with

federal standards. Oxygenates are also used in reformulated gasoline year-round to dilute the volumes of other less desirable compounds , such as benzene, sulfur, aromatics and olefins. When the presence of these compounds is reduced to achieve compliance with the RFG regulations, octane is lost and must be replaced by mixing a high octane blendstock back into the gasoline. Oxygenates can and do serve this purpose.

Differences: Ethers exhibit many characteristics that are similar to gasoline and therefore do not pose any major challenge for the distribution infrastructure of pipelines, pumping stations, terminals, storage tanks, loading racks, delivery trucks, underground tanks and pumps at retail service stations.

Table 3 illustrates the difference in characteristics between the two classes of oxygenates. For example, the energy density for ethanol is 76,000 Btus per gallon, while the three ethers range from 93,500 to 100,600 Btus per gallon. This higher energy content, along with some other positive blending characteristics, make ethers a more desirable class of oxygenate for the refining industry.

Ethanol exhibits two characteristics that pose difficulties for distribution and compliance with certain gasoline specifications. First, ethanol has a great affinity for water, meaning ethanol will easily mix with any water encountered by ethanol in the distribution system, reducing the energy content of the ethanol and introducing problems with engines operating on gasoline containing contaminated ethanol. Because of this problem, ethanol is not blended with gasoline prior to shipment through the pipeline system, rather, ethanol is “splash-blended” with gasoline in the tanker truck prior to delivery to service stations. Ethers do not have an affinity for water (just like gasoline). Water that is normally found in small amounts throughout the distribution system does not mix with gasoline and can be drained from storage and automobile tanks because it separates from the gasoline and lies on the bottom of these tanks.

When ethanol is splash blended with gasoline, necessary precautions must be undertaken to ensure that the final blend of gasoline and ethanol will not violate the Reid vapor pressure (Rvp) standard, one of the fuel specifications regulated by state and federal regulatory agencies. Ethanol blended with gasoline tends to increase the Rvp of the finished gasoline greater than any of the ethers. As a consequence, gasoline shipped to terminals for splash-blending must contain an Rvp lower than normal (during the summer months) so that the final blended product does not exceed the Rvp standard. These batches of lower than normal Rvp gasoline are costlier to produce and require additional segregation from the other types of gasoline at the refinery. At the terminals, the ethanol used for splash-blending must also be stored separately and special equipment must be installed to allow for splash-blending.

Table 3
Blending Characteristics of Oxygenates

Property	MTBE	TAME	ETBE	Ethanol
Fungibility in Gasoline Distribution System	High	High	High	Low
Energy Density - MBtu/gal (LHV)	93.5	100.6	96.9	76.0
Oxygen Content (wt.%)	18.2	15.7	15.7	34.7
Amount required to achieve 2.0 wt.% oxygen level in reformulated gasoline (volume percent)	11.0	12.4	12.7	5.7
Amount required to achieve 2.7 wt.% oxygen level in reformulated gasoline (volume percent)	14.8	16.7	17.1	7.7
Amount required to achieve 3.5 wt.% oxygen level in reformulated gasoline (volume percent)	19.2	21.7	22.2	10.0
Solubility in Water (wt.%)	4.30	1.15	1.20	Infinite
Blending Rvp (psi)	8.0	2.5	4.0	18.0
Octane Blending (R+M)/2	110	105	112	115
Vapor Pressure Neat Rvp (100 Degrees F.)	7.80	1.50	4.40	2.30
Boiling Point (Degrees F.)	131	187	164	172
Density @ 60 degrees F. (lb/gal)	6.19	6.41	6.25	6.61
Latent Heat of Vaporization - MBtu/gal (@ N.B.P.)	0.86	0.90	0.83	2.39

Notes:
MBtus/gal - Energy content in thousands of British thermal units per gallon.
LHV - Lower heating value.
wt.% - weight percent
Rvp - Reid vapor pressure.
psi - pounds per square inch
(R+M/2) - An arithmetic average of the Research and Motor octane values.
Octane - Measure of the antiknock performance, the higher the number, the greater resistance to knocking.
N.B.P. - normal boiling point